International Conference on
Geomembranes
Denver, U.S.A.

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Automated Fabric Dam Aids Water Research Project

The fabric dam has adequately controlled the stream levels to meet its design purposes for a two year period. In the future other type structures may be developed to control stream water levels and pass flood waters and rafts of weeds as well as the Fabridam.

One of the features of stream water level control is the raising of the water table levels in the fields which have furnished water to increase crop yields by 36% over the two-year period. Secondly, an underground lake was formed in the surrounding area that supplied 352,840 M^3 of water which was pumped from Mitchell Creek in 1983.

The structure cost was $248,700 installed. A present value analysis based on increased yields showed the Fabridam would pay for itself on this location in 15 years and leave $22,200 ($1,480/Y) for maintenance and management. In addition, irrigation water was available for 6-center pivot systems, 3 traveling volume gun systems, and one subirrigation system.

Need for Study

Water conservation is a major concern in many irrigated areas of the world. In many agricultural water resource projects improvement in open channel flow is needed to control floods and to provide better drainage. During drier periods, however, these deepened channels may continue to lower the water table and crops may suffer from drought. Controlling stream water levels to store water in the soil is now being studies in North Carolina as a possible solution to these problems.

An agricultural research project sponsored jointly by United States Department of Agriculture, Agriculture Research Service, Soil Conservation Service and North Carolina State University was established in 1978 to study this problem. The project study area, approximately 800 hectares in Edgecombe and Pitt Counties, North Carolina, is a part of the Conetoe Creek Watershed project constructed under the Soil Conservation Service Public Law-566 Flood Prevention Program. Mitchell Creek Main serves the area as the outlet channel (2). To meet project objectives a structure was needed in this channel that would control the stream water level during the growing season but would automatically open during heavy rains to allow flood flow to pass without causing crop damage.

A heavy growth of aquatic weeds in the nutrient-rich water of Mitchell Creek further complicated the problem. Experience had shown that, during major floods, these weeds break loose from the channel bottom in mass and are carried rapidly downstream, possibly causing channel blockage and subsequent failure of the structure.

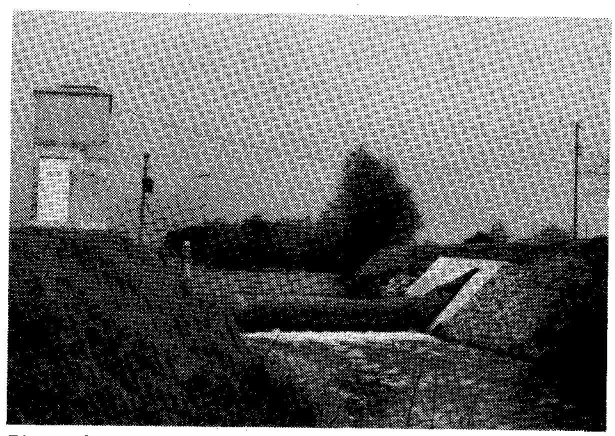

Figure 1. The Water Inflatable Fabric Dam on Mitchell Creek near Tarboro, North Carolina, U.S.A.

A fabric dam (Fabridam) (Fig. 1) was selected as the type structure that would allow the weed mass to pass and also allow desired automation. This type structure made of 2-ply neoprene coated nylon is attached to a concrete pad placed to fit the channel cross-section. By filling with water, the dam can be raised or lowered to any desired elevation. During floods the Fabridam automatically deflates flat on its pad allowing flood water and any weed accumulations to pass unrestricted. Holding water at a high level in the channel early in the growing season allows water to remain in the soil that would otherwise be lost (1). Runoff from rain can either be stored or released depending on crop needs (3). This type water management is limited to locations that have seasonally excess rainfall, are nearly level, and have soils on which crops respond well to drainage but in many years supplemental irrigation is beneficial. It is estimated, however, that as many as 5 million hectares in the southeastern part of the United States alone could benefit if water table levels were properly controlled (4).

The objective of this water research project is to learn the most practical way to manage the water table in certain soils to produce optimum yields, and determine the amount of supplemental water stored. The purpose of this paper is to acquaint others with this effort and to provide them with specific information on how an automatic structure can be installed and effectively used to help accomplish this objective.

Construction of the Fabric Dam

The dam is on an earth channel that was excavated as part of a Public Law-566 flood prevention and drainage project completed 17 years ago. The channel was approximately 3.3 meters deep with a 5.3 meter bottom width with 1:1 slide slopes. Soils in the channel bottom and sides are silty sands and poorly graded sands.

An earth by-pass channel (Fig. 2) was excavated around the right side of the work area to handle stream flow during construction. Coffer dams were constructed across the stream channel approximately 17 meters upstream and downstream from the work area.

Interlocking steel sheet piling was driven across the channel to a depth of about 4 metres below the channel bottom and extending approximately 5 meters into the edges of the bank on each side. The piling was to reduce seepage below the structure (Fig. 2).

A well field was installed around the proposed channel work and vault building to remove seepage water during construction (Fig. 2). Handling seepage water was a problem during the early stages of conconstruction without the well field.

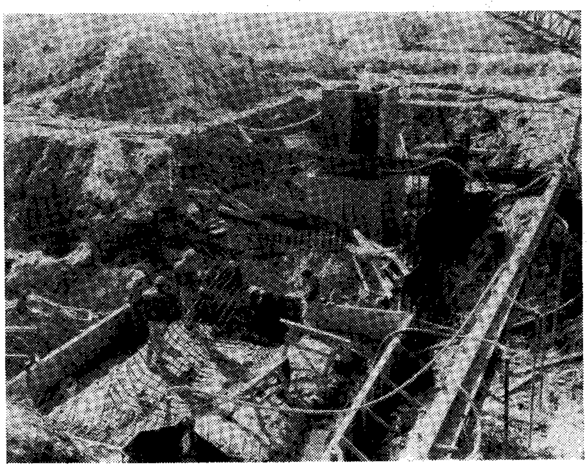

Figure 2. Early construction phase of the Fabridam showing the by-pass channel in background, the interlocking sheet piling, the well point system for dewatering and the third pour conditions for the vault building.

The vault building contains the pumps, valves, and controls necessary to operate the inflatable dam. The building is located in the right side of the channel looking downstream. It is approximately 10 meters in height and 2.9 meters by 2.4 meters of the base. The building is a reinforced concrete structure poured in lifts. The bottom elevation of the structure is approximately 0.7 meters below the elevation of the channel bottom. The exterior of the building was treated for water tightness up to ground level. A sump pump was installed in the base of the building to pick up seepage. After the first two pours of concrete on this building, the work on the channel structure was started (Fig. 2).

The channel bottom and sides were excavated and shaped to accept the placement of the reinforced concrete slabs. The top of the steel sheet piling was cut off parallel and approximately 30 centimeters below the finished surface of the concrete slabs. The top of the steel piling is embedded in the upstream edge of the concrete slab. The surface of the slab was poured flush with channel bottom and sides. The surface of the slab were trowled to a hard smooth finish.

The upper part of the vault building was completed. The top 1.8 meters of the building is a tank for holding make up water for the dam. A 5-HP pump keeps the tank full. There are five pipes that extend from the lower portion of the vault building. Two pipes extend upstream from the building. One is a sensing line. The other is water intake line for the tank and bag.

Two pipes exiting into the inflated area extend under the concrete floor of the dam to the control vault. One pipe is a sensing line. The other pipe is used to inflate and deflate the dam. This pipe extends through the control vault downstream and exits near the channel bottom to deflate the dam.

Stainless steel anchor bolts are located on 30 centimeters center in the concrete slab bottom and sides. (Fig. 3). The bolts attach the bag material at its upstream and downstream edges. The bag is made of nylon reinforced synthetic rubbererized material, approximately 0.32 cm thick. An epoxy coating was applied to the concrete slab under the dam and to the area that will be in contact with the bag when deflated. This coating insures a watertight connection with the bag and reduces abrasion.

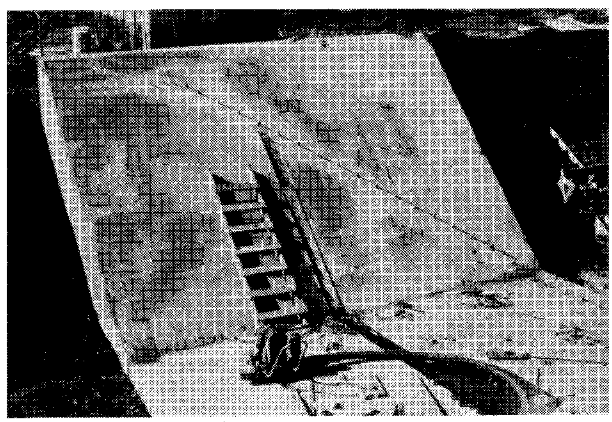

Figure 3. Side wall and bottom of the concrete pad on which the Fabridam rests showing bolts to hold the fabric and make the water tight seal to the pad.

A single-ply nylon, neoprene coated seal sheet was laid on the surface of the concrete slabs covering both the upstream anchoring bolts and the downstream anchoring bolts. This sheet ensures watertightness.

The bag material was cut to fit the anchor bolts. Anchoring plates cover the bag material and bolts. They are held in place with stainless steel nuts. This forms a watertight connection with the concrete surface (Fig. 4). A lot of effort was necessary in fitting, cleaning and attaching this material. The bag was inflated with air to check for leaks.

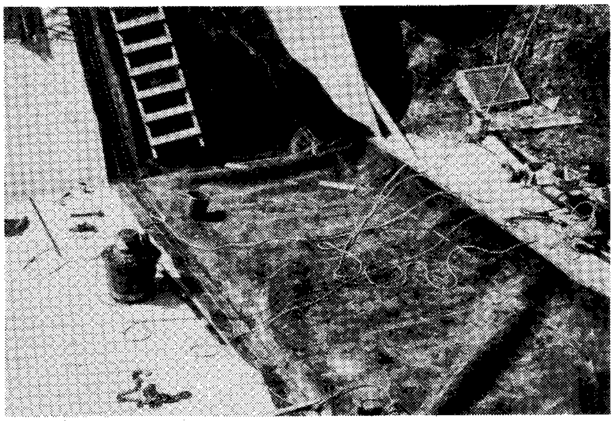

Figure 4. The excess fabric of the Fabridam was folded to form a smooth surface for the dam to rest on when deflated.

A reverse filter system was installed downstream from the concrete slab in the bottom and sides of the channel (Fig. 5). This is a graded filter that is composed of small riprap on the surface underlain with layers of gravel and sand for a combined thickness of 0.9 meters. The riprap layer was grouted leaving many openings for water movement. The top surfaces of the filter are flush with the surfaces of the concrete slabs. This filter is to reduce hydrostatic pressure under the concrete slab and to prevent scouring below.

With the bag satisfactorily installed and controls in the vault building in place, the two coffer dams were removed. The by-pass channel was filled in and the area graded so that the earth adjacent to the vault building was approximately 0.5 meters higher than the surrounding area. The entire disturbed work area was vegetated with a perennial grass.

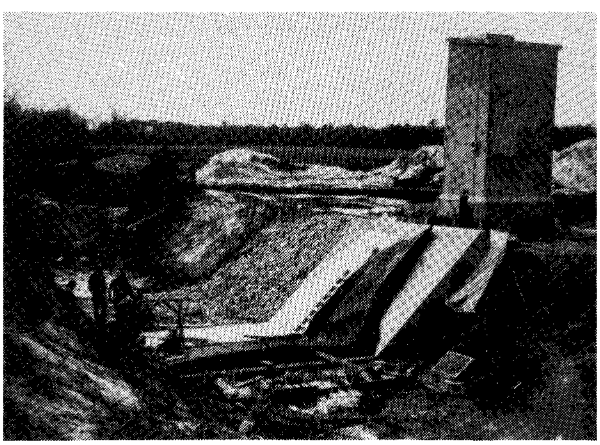

Figure 5. Reverse filter downstream of the Fabridam.

Operation and Performance of Fabridam

The 2.7 meter high Fabridam structure (Fig. 1) was installed across Mitchell Creek about midway in the 3.5-km study area and put into operation on April 2, 1982. The water inflatable fabric dam is about 6 m wide at the bottom of the creek bed and 13 m wide at bank height. The dam is used to automatically control the water level in the creek. The Fabridam collapses during flooding which allows the channel to carry full design flow. It can automatically control the water level in the channel to any depth up to 2.45 m. For example, if the control level is set at 11.45 m above Mean Sea Level and a flood raises the upstream level to 11.60 (0.15 m rise), the Fabridam begins to deflate, but will remain controlled between 11.45 and 11.60 m. If the flood level continues to rise to 11.62 m (.17 m rise), another valve opens and the Fabridam deflates faster, but automatic controls keep it between 11.45 and 11.60 m. If the flooding continues and the upstream water level reaches 11.65 m (0.2 m rise), a 20.3-cm syphon will deflate the Fabridam at a rate of about 0.06 m/min until there is no restriction to flow in the channel. As soon as the flood passes and the syphon breaks, the Fabridam inflates to the original setting of 11.45 m.

Water Level Controls

Controlling the stream water levels affected the water table levels in the soil of adjacent lands for a distance of 900 m from the creek. Near the creek the water table was about 1.5 m closer to the ground surface after the Fabridam was installed and from about 400 m to 900 m from the creek the water table was about 0.5 m closer to the surface. The 3-dimensional water surface from 305 m below the Fabridam to 1135 m above the structure and from Mitchell Creek to 621 m to the right looking upstream at the Fabridam is presented in Figure 6. Below the Fabridam, the water table surface near Mitchell Creek was at about 3 meters below the soil surface and increased to about 1.5 meters from the surface at 621 m from the stream. Gradients in the water table surface in the channel direction near the Fabridam indicated soil water flow around the dam to the low stream elevation below the dam. The water table surface was essentially controlled in a flat condition above the Fabridam over the 65-ha area and 1135 meters upstream from the Fabridam (Figure 6). Most of the variations in water table depth was due to soil surface variations. The water surface in the soil adjacent to Mitchell Creek was successfully regulated by stream water level control in the creek. These data show that future design of water resource projects should consider both drainage and water table control.

Irrigation Water Available

Controlling the stream water level provided an underground lake from which irrigation of crops was made possible. For example, before the Fabridam was installed to control the stream water level, only one center pivot system and one traveling volume gun were able to pump enough water from Mitchell Creek and then they could pump less than 12 hours each day. In 1983, with the stream water level controlled, water was pumped from Mitchell Creek and the underground lake (Fig. 6) to supply 6-center pivot systems, 3-traveling volume guns and one subirrigation system. A total of 352,840 m^3 (35.3 hectare-m) was pumped from above the Fabridam in 1983. Figure 7 shows the accumulated water pumped for irrigation in relation to the stream water level and the water table surface in relation to distance from the creek. The top of the Fabridam was set to control the stream water level at 11.45 m above Mean Sea Level during the corn growing season. Anytime the stream water level

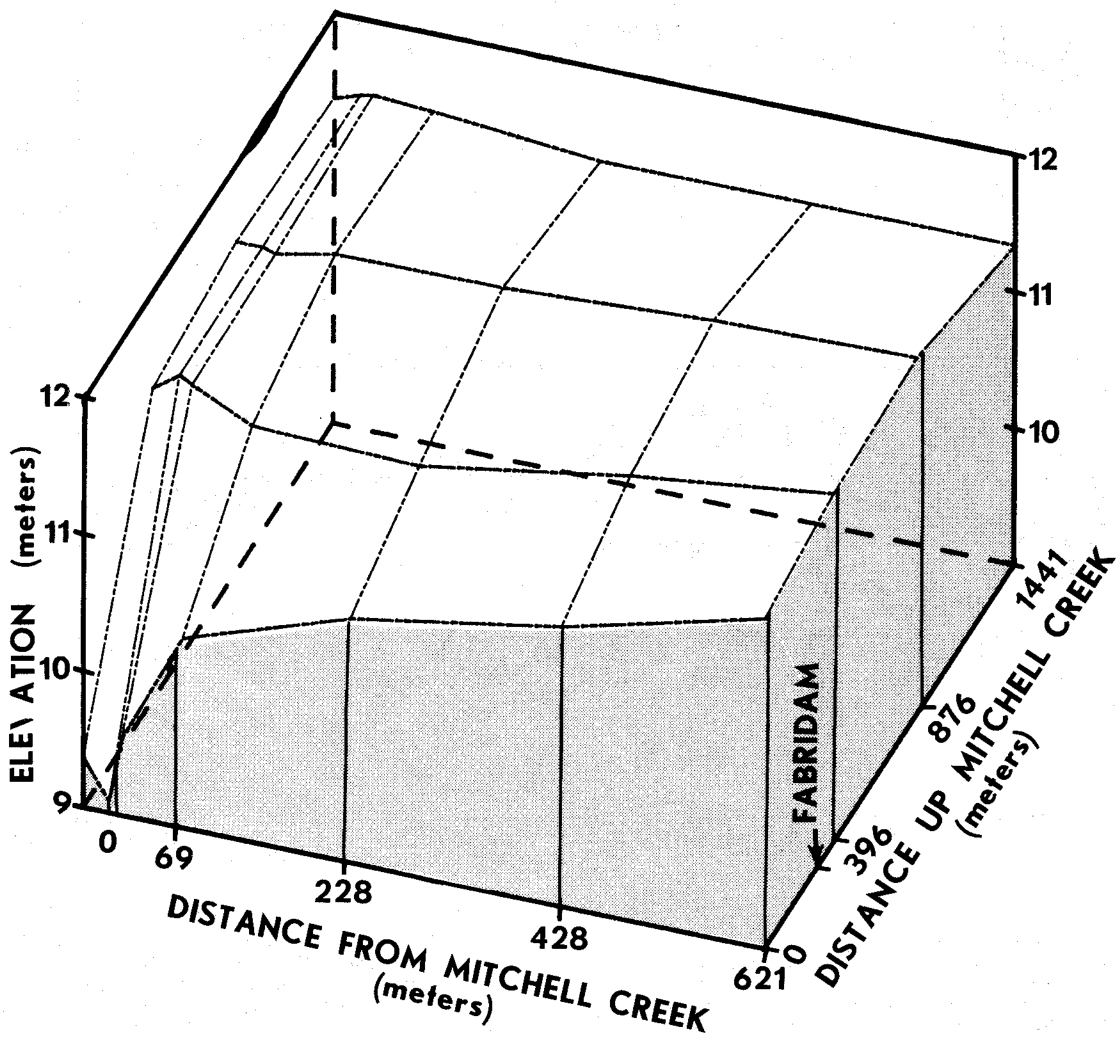

Figure 6. Three dimensional relationship of water table surface from 305 meters below the Fabridam to 1135 meters above the structure and to 621 meters away from Mitchell Creek on July 10, 1982.

receded below 11.45 m the stream was not flowing over the Fabridam and downstream flow was supplied by seepage through the soil. The pumping of 31.2 ha-m of irrigation water lowered the stream water level 0.82 m. This lowered the ground water level 0.69 m at 9 m from the creek, 0.58 m at 85 m from the creek and 0.33 at 610 m from the creek. As the water was pumped from the creek lowering the stream water level, water flowed into the creek from the underground lake allowing 312,000 m^3 of water to be pumped for irrigation purposes.

Corn Yields

Corn yields were sampled by hand from 3 x 2 m plots over the area above the Fabridam (control) and below the Fabridam (no control). Some fields were irrigated and some were not. Stream water level control increased corn yields by 36% over the no control area in nonirrigated fields and by 26% in irrigated field for the 1982 and 1983 cropping seasons (Table 1).

Table 1. Corn yields as affected by controlling stream water levels with a Fabridam.

Stream Water Level	1982		1983		Mean	
	Surface Watering					
	Nonirr.	Irr.	Nonirr.	Irr.	Nonirr.	Irr.
	t/ha					
Control	8.32b[1/]	10.33a	5.42c	9.96a	6.87	10.15
No Control	6.93c	8.29b	3.19d	7.77b	5.06	8.03

1/ Yields followed by the same letter within the same year are not significantly different at the 5% level DMRT.

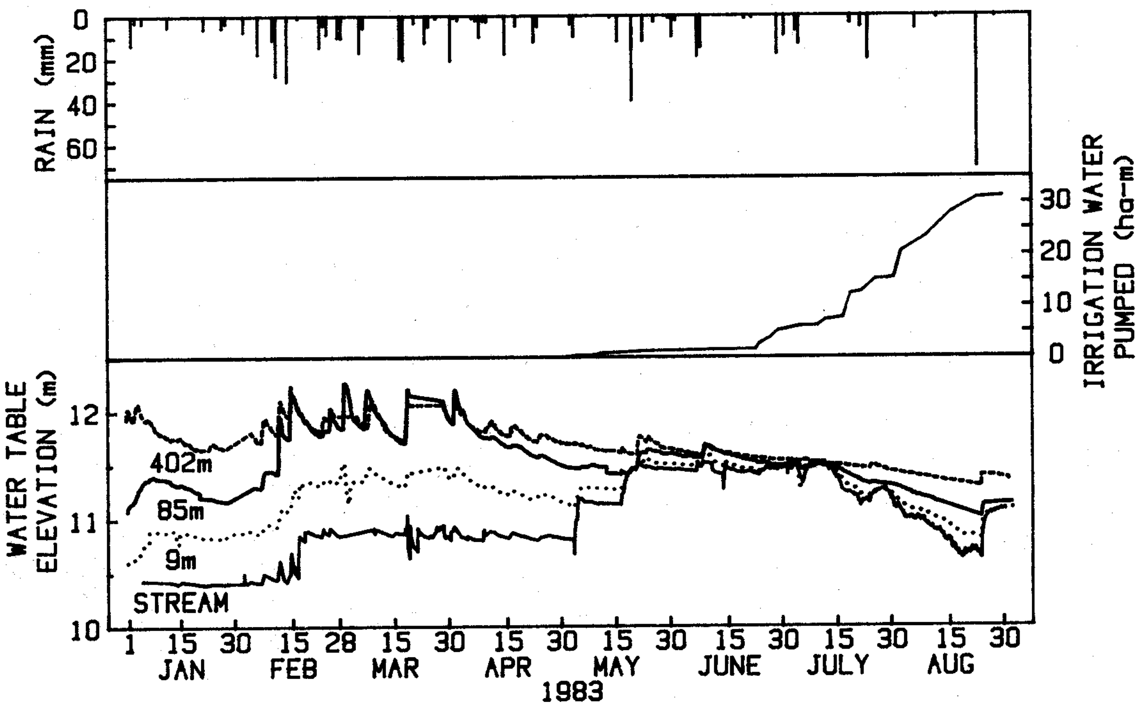

Figure 7. Relationship of rainfall, irrigation water pumped and water table elevations at various distances from Mitchell Creek in 1983. The control level of the Fabridam was set at 10.4 m until February 16, 10.8 m until May 4, 11.1 m until May 17, and 11.5 m from May 17 through the rest of the cropping season.

Table 2. Present value of a corn crop on the Mitchell Creek area with and without stream water level control at $98.40/ton ($2.50/bu) projected for 15 years at 10 percent interest (PWF = 7.606). The estimated life of the Fabridam is 50 years.

Stream Water Level Mgmt.	Average[1/] Yield	Area	Present crop value[3/]	Present Mgmt. cost	Returns for maint. & mgmt.
	(t/ha)	(ha)[2/]	----------dollars---------		
Control	6.87	200	1,028,300	24 ,700	779,600
No Control	5.06	200	757,400	-	757,400
Increase due to control	1.81	-	270,900	248,700	22,200

1/ Average yield for 1982 and 1983.
2/ Water table affected at least 2200 m upstream and 450 m on either side of creek.
3/ Present crop value = 757,400 = 5.06 t/ha x 200 ha x $98.40/t x (PWF = 7.606) - rounded to $100

The Fabridam cost $248,700 installed. This high cost was in part due to it being a prototype in the area. However, based on the average corn yield data for 1982 and 1983, structures as expensive as the Fabridam will pay for themselves in these sandy soils over a 15 year period and leave a balance of $22,200 ($1,480/year) for maintenance and management (Table 2). This does not include the fact that 352,840 m^3 additional water was stored and pumped for irrigation in 1983.

Acknowledgement

The Fabridam is a patented structure by N. M. Imbertson & Assoc., Inc., Burbank, CA, designed specifically for this project from ARS specifications. Mention of this trademark does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agric. and does not imply its approval to the exclusion of other products or structures that may also be suitable.

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